National Aeronautics and Space Administration

Optics

Micro-LIDAR for Flow Velocimetry

Advanced boundary layer flow analysis without particle-seeded flows

NASA's Langley Research Center has developed a miniaturized light detection and ranging (LIDAR) velocimetry sensor to analyze high velocity and boundary layer flows in real-world conditions. Using Rayleigh scattering, as opposed to the more common particle scattering, the patent pending NASA sensors provide multiple flow parameters without the need for particle-seeded flows. The compact fiber-optic sensor design can be embedded directly in a test surface and allows for a variety of near-surface measurement formats enabling real-time, three-component flow velocity mapping, composition, gas density, and temperature data. The versatility of the NASA Micro-LIDAR sensor platform offers broad utility in advanced aerodynamic and fluid dynamic applications requiring boundary layer, unseeded flow measurements.

BENEFITS

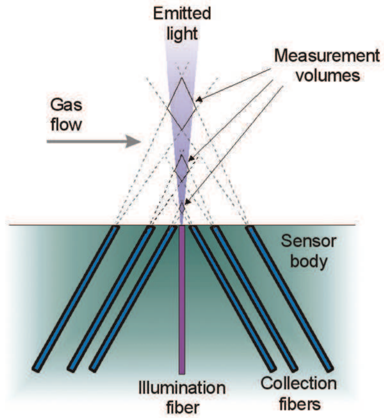
- Compact and lightweight format, embeddable as a single point or distributed array sensor in test surfaces (e.g., wind tunnel model, aircraft wings, engines)
- No need to seed test flow with particles, allowing use in real-world applications and supersonic and hypersonic flows
- Real-time flow measurement (10-nanosecond event resolution at up to 10 kHz rate)
- Miniature laser/detector platform reconfigurable to provide flow composition, temperature, pressure, and particle sizing data
- Pitot probe replacement on supersonic or hypersonic aircraft to provide pre and post-shock density, temperature, velocity, and Mach number

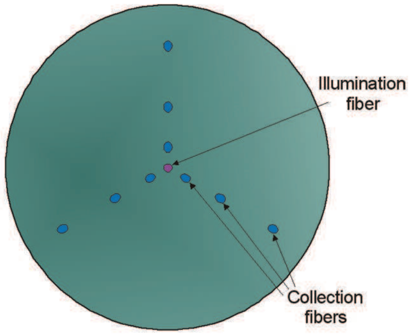
technology solution

THE TECHNOLOGY

The novel NASA Micro-LIDAR sensor was developed to enable high speed (supersonic and hypersonic) boundary layer flow analyses in wind tunnels and flight vehicles without the need for particle-seeded flow. The velocity of a gaseous flow can be optically measured by sending laser light into the gas flow and then measuring the scattered light signal that is returned from matter within the flow. Scattering can arise from either gas molecules within the flow itself, known as Rayleigh scattering, or from particles within the flow, known as Mie scattering. Mie scattering provides a much larger return signal than Rayleigh scattering and is the basis of all commercial laser Doppler and particle imaging velocimetry systems, which require particle seeding of the flow and are time-of-flight techniques.

The NASA Micro-LIDAR sensor combines high laser intensities over a small flow volume near a surface and good signal collection efficiencies to enable Rayleigh scattering measurements, which eliminates the need for particle-seeded flows. In addition to unseeded flow velocimetry, the NASA sensor format can be reconfigured as spectroscopy, induced fluorescence, and differential measurement devices to provide flow composition, gas density, temperature, and pressure data. The multi-parameter miniaturized NASA sensor format provides for an unobtrusive in-flight method to determine laminar versus turbulent flow in the boundary layer. When combined with surface actuators in a closed loop control system, the NASA sensor creates the potential for active boundary layer control. The combination of real-time measurements, embedded sensor arrays, and unseeded flow capability embodied in the NASA sensor platform provides industry a powerful real-world flow analysis tool.





Micro-LIDAR measurement configuration for wall-mounted probe

APPLICATIONS

The technology has several potential applications:

- Aerodynamics - Provides in-flight or wind tunnel surface velocimetry measurements for boundary layer monitoring (e.g., wing, fuselage, engine).
- Aerospace - Embedded sensor format enables potential closed loop boundary layer control system to manage turbulent flow.
- Aviation - Compact probe can be mounted inside nozzles and engines.

PUBLICATIONS

Patent No: 7,675,619

More Information

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